

# MIXED LOGIT ESTIMATION OF RADICAL ISLAMIC TERRORISM IN EUROPE AND NORTH AMERICA: A COMPARATIVE STUDY

by

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## Abstract

This paper estimates what characteristics (e.g. location, number of casualties, and type of attack) are associated with an Islamic terrorist attack. This is established by identifying the significant determinants of the probability that an attack had been carried out by Islamic terrorists. For Europe, the United States, and Canada, the analysis employs ITERATE data from October 1979 to December 2002 to ascertain the significant characteristics of Islamic terrorist attacks. A random-parameter logit model is used to analyze the probability of such attacks, taking into account the heterogeneity of the sample data. This model outperforms the standard logit model. Some policy implications are presented.

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**Key words:** Islamic radical terrorism, mixed logit model, and public policy.

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Our data are available at <http://www.yale.edu/unsy/jcr/jcrdata.htm>.

## 1. INTRODUCTION

Western societies in the early years of the twenty-first century must confront complex and multi-dimensional social, political, economic and cultural factors, which require extensive research in various disciplines, if they are to approach an understanding of why radical Islamic terrorism has proliferated across the world. The growth trend in radical Islamic terrorism, which reached an unprecedented scale on September 11 2001, more or less coincides with the dwindling of Communist state-sponsored and other leftist terrorism. Radical Islamic terrorism is, in its aim, similar to the terrorism which was common in Europe during the 1970s, in as much as one of its goals is the destruction of the capitalist system (Richards, 2003). The evolutionary pattern means that there is a variation in the acts of terrorism along the time, whilst under the definition of terrorist events, there are different types of political demands (Donno and Russett, 2004).

The research presented in this paper analyzes the characteristics of radical Islamic acts of terrorism in European countries, the United States and Canada between October 1979 and December 2002. The motivation for this research stems from three critical issues associated with radical Islamic terrorism: first, the unprecedented nature of the radical Islamic terrorist attacks that befell New York City and Washington DC on 11 September 2001 (employing civil airliners as weapons of mass destruction) and Madrid on March 11 2004 (bombing rush-hour commuter trains); second, the consequent scale of victimization achievable and achieved by such methods, combined with the threat of obtaining and using methods that would wreak even greater indiscriminate carnage on civilian populations; and lastly, the escalating dangers of the social, economic, political and even psychological impacts on the continuing viability of the capitalist system and way of life, implied by the failure to prevent such attacks.

The paper contributes to the theme's literature in five ways. First, it uses the random-parameters logit model (RPL), previously used by Train (1998) and Revelt and Train (1998), which allows for heterogeneity in the data set. Second, it specifically analyzes radical Islamic terrorist events, an issue that so far has not inspired much research in Europe, despite its contemporary importance. Third, it analyzes terrorist events on both sides of the Atlantic, which are tied by the same market system as well as the same threat. Fourth, it uses panel data, whereas time-series analysis is usually used. Lastly, it investigates the targeting of United States citizens outside the USA, a phenomenon linked to Islamic terrorism, and which has not attracted research so far.

The paper regresses the probability of a terrorist attack being perpetrated by an extremist Islamic organization on its characteristics, using a mixed logit. The model permits the identification of significant statistical characteristics that estimate the probability of a terrorist attack to be Islamic, as opposed to a non-Islamic. The value of such research is that it could contribute to policy formulation in the war against terrorism. If one knew the characteristics identifying Islamic events, then one could better allocate resources used in countering such events.

The paper is organized as follows: in the second section, we briefly describe the contextual setting and its antecedents; in section 3, the existing literature is surveyed; in section 4, we present the mixed logit model; in section 5, we present the theoretical framework; in section 6, the data is set out and the results presented; and finally, in section 7, we give our conclusions.

## **2. TERRORISM IN EUROPE, THE USA AND CANADA**

The character and motivation of the first terrorist groups to emerge in the Middle East in the late-1960s were political, rather than religious; that is, Marxist, anti-western and anti-capitalist. They were secular, revolutionary movements, a minority of the tendency proliferating amongst young, extreme left-wing intellectuals and the disaffected globally, against the background of ideological conflict and confrontation of the Cold War, most ostensibly present in the US involvement in Vietnam. They found sponsorship in states such as the Soviet Union and certain Arab countries. Radical Palestinians began to internationalize and urbanize their conflict with aerial hijackings, kidnappings, bombings and assassinations, involving western civilians for the first time.

Two major events of 1979, the Islamic Revolution in Iran and the Soviet invasion of Afghanistan, were to determine, in the short and long terms, an evolution from secularist, politically-motivated terrorism towards the radical Islamic form. The assassination by members of the Muslim Brotherhood of President Anwar Sadat in Cairo in October 1981 brought to the world's attention the extent of developing militant Islamic radicalism.

Turning now to the acts of terrorism themselves, Table 1 below presents the aggregate characteristics of terrorism events from October 1979 to December 2002. Our sample covers the following countries: Austria, Belgium, Canada, Denmark, Finland, France (including Corsica), Germany (including the former German Democratic Republic), Greece, Iceland, Ireland, Italy (including the Vatican), Netherlands, Norway, Portugal, Spain, Sweden,

Switzerland, the UK (including Northern Ireland) and the USA. Besides these countries, we have considered also a residual category named ‘Other European Countries’.

Table 1: Terrorist Events, October 1979 to December 2002

Variables	Total	Islamic	Non Islamic	Equality in means <i>t</i> test	
				t-stat	p-value
Terrorist Events	2799	386	2413		
Armed Attack	163	21	142	-0,355	0,72
Arson	389	8	381	-13,2088	0,00
Assassination	249	75	174	5,863	0,00
Bomb	1068	102	966	-5,535	0,00
Kidnap	35	4	31	-0,440	0,66
Letter bomb	65	7	58	-0,789	0,43
Skyjacking	74	11	63	0,263	0,79
Wounded	7157	3818	3339	1,438	0,15
Killed	4092	3528	564	1,223	0,22
US victims Outside USA	1076	584	492	0,169	0,87

Radical Islamic terrorist attacks constitute 13.8% of all terrorist events. The most common type of terrorist method is explosive bombs, followed by arson (which also includes incendiary bombing and Molotov cocktails), assassination and armed attacks. Letter or parcel bombing and aerial hijacks are less common. Islamic terrorists reveal a different hierarchy of preferences for the type of the attack, with assassination the second favorite method, followed by armed attack and arson (in this order). Despite the fact that the use of bombs is their most favored type of attack, they resort much less to it than non-Islamic terrorists. The same table includes the result of a *t*-test for the equalities in the means in terms of the different characteristics of Islamic attacks relative to non-Islamic attacks. The results show that Islamic groups resort significantly less to bombs and arson and significantly more to assassination than non-Islamic groups. For the other characteristics, there are no significant differences in the mean.

The average casualties (wounded plus killed) resulting from an Islamic extremist attack for the entire period under analysis are much higher than those from a non-Islamic attack, but this value is greatly influenced by the extremely high number of casualties in the September 11 events. Considering the average number of casualties before 2000, the difference between Islamic and Non-Islamic terrorist events is not so significant, with an average of 4.1 for the former and 1.7 for the latter. Moreover, for the whole period, the

results of the  $t$ -test cannot detect significant differences between the mean numbers of wounded and killed in Islamic attacks and those in non-Islamic attacks.

Table 2: Characteristics of Terrorist Events by country: October 1979 to December 2002

Variables	Austria	Belgium	Canada	Denmark	France	Germany	Greece	Ireland
Terrorist Events	59	66	26	26	428	542	282	28
Radical Islamic	16	11	4	4	84	46	39	0
% of Rad. Islamic	27.1	16.7	15.4	15.4	19.6	8.5	13.8	0.0
Armed Attack	4	5	0	3	23	47	23	1
Arson	4	4	0	2	20	122	53	4
Assassination	9	5	5	1	48	30	26	1
Bomb	19	24	1	8	217	114	137	9
Kidnap	0	2	0	1	6	2	1	4
Letter bomb	2	1	0	1	5	5	1	0
Skyjacking	0	0	0	0	7	12	3	0
Wounded	84	137	52	31	1037	877	400	6
Killed	17	16	5	2	137	80	57	2
US victims	6	4	0	4	48	232	173	1
Variables	Italy	Netherl.	Portugal	Spain	Sweden	Switzer.	UK	USA
Terrorist Events	198	45	56	216	38	58	395	312
Radical Islamic	49	11	3	23	9	16	34	35
% of Rad. Islamic	24.7	24.4	5.4	10.6	23.7	27.6	8.6	11.2
Armed Attack	11	0	7	12	3	4	10	9
Arson	20	3	0	16	2	5	103	28
Assassination	27	6	4	18	2	8	23	29
Bomb	75	14	34	123	3	20	164	102
Kidnap	3	1	0	5	1	1	4	4
Letter bomb	0	1	1	6	2	0	24	16
Skyjacking	5	0	0	6	5	2	5	22
Wounded	566	12	10	212	6	97	1190	2434
Killed	157	14	12	48	4	9	417	3115
US victims	116	2	2	73	1	7	401	5677

Obs: The percentage of Radical Islamic attacks refers to the total number of attacks in the country

Table 2 presents the results of terrorist events by country examined. Radical Islamic terrorism is a representative phenomenon among terrorist incidents of all origins in most of the countries analyzed, with France, Italy and Germany displaying the highest number of radical Islamic terrorist incidents, followed by Greece, the UK, the USA, Spain and Switzerland, in that order. However, Switzerland has the highest rate of this type of incidents, maybe because it hosts various international institutions and frequent international meetings and conferences, which may constitute priority targets for radical Islamic terrorists. Portugal has the lowest rate of Islamic attacks. When we restrict the analysis to the last three years (2000-2002), the rate of radical Islamic terrorism for the USA increases dramatically to 67%, corresponding to 6 events out of the total of 9. This pattern is also registered by Italy, where the proportion of Islamic terrorism increases to 83%, but this figure should be analyzed with caution in view of the small number of terrorist events occurring in this country during the period analyzed. Other countries display some or no terrorist events at all in the same period. The total number of US victims varies from country to country, as does the number of wounded and killed. The UK, Greece, Italy and Germany display the highest averages of US victims in foreign countries: 1.02, 0.61, 0.59 and 0.43 respectively, while the USA, the UK, Italy and France are the countries with the highest average casualties. The high rate of US victims in the UK can be explained by the Pan Am Flight 103 incident in December 1988, resulting in a total of 270 deaths. However, the average casualties in the USA before 2000 drops considerably to 0.45, being one of the smallest figures observed. Portugal, Spain, France and Greece have the highest percentage of terrorist attacks using bombs, 61%, 57%, 51% and 49% respectively, while the UK, Germany and Greece are the countries in which the rate of the arson type of attacks is greatest, 26.1%, 22.5% and 18.9% respectively. Assassination has a higher share in Canada, Belgium and Austria, with rates of 19.2%, 18.1% and 15.3% respectively.

### **3. LITERATURE SURVEY**

The economics literature on terrorism is restricted both in terms of the number of papers and the number of authors (for a relatively up-to-date survey, see Enders and Sandler, 1995). Two main types of analyses are in evidence: time series models and cross-section or panel data models. Papers in the time series tradition use intervention analysis, in which the number of terrorist incidents is regressed on indicators of policy intervention, to evaluate the effectiveness of policy (Enders and Sandler, 1993). Alternatively, time series models use

economic-impact analysis, in which the foreign direct investment is regressed on terrorist incidents to evaluate the economic impact of terrorism on the economic variables (Enders and Sandler, 1996). Enders and Sandler (1991) used a VAR (vector auto-regression) first-order to estimate the economic impact of terrorism on tourism in Spain during the period from 1970 to 1988. Enders (1995, pp. 316-320) presents a pedagogical review of the previous paper. Enders, Sandler, and Parise (1992) analyzed the economic impact of terrorism on tourism receipts, using quarterly data for 12 countries from 1970:I to 1988:IV with a transfer function. Enders and Sandler (1996) analyzed the economic impact of terrorist actions on foreign direct investment in Spain and Greece with quarterly data from 1975:I to 1991:IV for Spain and 1976:I to 1991:IV for Greece. They concluded that an average year of terrorism led to a persistent, negative impact on foreign direct investment of 13.5% for Spain. For Greece, this annual negative impact on foreign direct investment was 11.9%. Drakos and Kutan (2003) analyzed the impact of terrorism in three countries: Greece, Turkey and Israel, with a simultaneous equation model, concluding that the tourism industry is sensitive to terrorist attacks. Sloboda (2003) assessed the effects of terrorism on tourism with yearly data from 1988 to 2001 for the USA by an ARMAX model, allowing for a trend and unit roots in the data. Abadie and Gardeazabal (2003) analyzed the economic impact of ETA terrorism on GDP, concluding that there was a 10% average gap between per-capita GDP in the Basque Country and the per-capita GDP of a comparable synthetic region that does not suffer from terrorism. Moreover, on analyzing Basque market-listed companies in comparison with non-Basque listed companies, they concluded that the former show a negative performance as an externality of terrorism.

Time series analysis is also used to analyze generic characteristics of terrorist attacks. Enders and Sandler (2002) analyzed the pattern of transnational terrorism with a Fourier model. Another paper employs time-series data with the aim of forecasting the future evolution of terrorist incidents (Enders and Sandler, 2002).

Papers employing cross-section and panel data are less common and include Atkinson et al. (1987), who examined the impact of changes in the negotiating environment on the length and severity of terrorist attacks and Li and Schaub (2004), who analyze the relationship between economic globalization and transnational terrorism, using a negative binomial regression for a sample of 112 countries from 1975 to 1997. Blomberg et al. (2002) analyze the importance of standard economic variables such as per-capita GDP growth and investment in determining the onset and intensity of terrorist attacks for a sample of 127 countries from 1968 to 1991, using a Markov model.

From this literature survey, we can observe that the results are focused on the implications of terrorism on specific economic variables. Concerning the econometric methodology employed, time-series dynamics and related issues, such as causality tests and trend breaks on terrorism events, are well understood. However, heterogeneity in the observed variable, spatial dispersion of the data and other issues related to cross-section data on terrorist attacks are less understood. In this paper, we enlarge on previous research by seeking the determinants of the likelihood of an Islamic attack, allowing for the heterogeneity inherent in the terrorist behavior and investigating the particular dispersion of the attacks by country. As far as we know, no other paper has estimated either the determinants of Islamic terrorist attacks, or the heterogeneity in terrorism variables.

#### 4. MIXED LOGIT

With the characteristics of an attack denoted by the vector  $x_i$ , the probability that the attack with characteristics  $x_i$  was instigated by Islamic terrorists as opposed to non-Islamic terrorists is denoted by  $P(\beta, x_i)$  with  $\beta$  a vector of unknown parameters. This probability is assumed to be logit and is equal to,

$$P(\beta, x_i) = \frac{e^{\beta' x_i}}{1 + e^{\beta' x_i}} \quad (1)$$

The logit is a highly popular model with regard to dealing with binary outcomes. Mcfadden (1974), Ben-Akiva and Lerman (1985) and Train (1986) used the logit model to relate the probability of making a choice to a set of variables reflecting decision-maker preferences. The logit is usually used as a behavioral model. In the present paper, we use the model in a slightly different approach, which is statistical, rather than behavioral. We estimate the probability of a terrorist event being carried out by an Islamic terrorist group, given a set of characteristics of the event, that is, we estimate  $\text{Prob}(\text{Islamic} | \text{type})$ , where *type* includes the particular attributes of the event. A behavioral approach to this problem would be  $\text{Prob}(\text{type} | \text{Islamic})$ , but the data set used does not allow for the estimation of such a model.

An alternative model is the random parameters logit (RPL) (also called mixed logit), which relaxes the assumption that the coefficients are the same for all terrorist events, allowing for some heterogeneity in the way the attack's characteristics determine the probability of it being carried out by an Islamic group. Therefore, this model is more flexible



than the standard logit and tests can be applied to determine whether this extra flexibility is needed in order to fit the data.

For the RPL model, an event  $i$ 's coefficient on some characteristic  $j$ ,  $\beta_{ji}$ , is a random draw from some distribution where the family of the distribution is specified, but the mean and variance are unknown and have to be estimated. We consider  $\beta_i \equiv \mu + \eta_i$  with  $\eta_i \sim F(0, \Omega)$ , independent of  $\varepsilon_i$ . When  $F(\bullet)$  is symmetric, it is usually considered to be the normal, and less often, the uniform or triangular distribution. If, for example, the coefficient can only assume positive values with asymmetric distribution,  $F(\bullet)$  is usually lognormal. The RPL probability of a radical Islamic terrorist attack is the integral of the standard logit probability in (1) over the density of the parameters,

$$P_i = \int_{-\infty}^{+\infty} \dots \int_{-\infty}^{+\infty} P(\beta, x_i) f(\beta | \mu, \Omega) d\beta. \quad (2)$$

The model estimates the coefficients mean,  $\mu$ , and the covariance between them,  $\Omega$ . Exact maximum-likelihood estimation is not possible, since the integral cannot be calculated analytically and requires simulation. Recently developed techniques for simulating probabilities (Train, 2003) have made it feasible to estimate such models. Applications include Train (1998), Revelt and Train (1998), Mcfadden and Train (2000) and Rouwendal and Meijer (2001). Observe that  $P_i$  is the expectation of,  $P(\beta, x_i)$  so that it can be calculated by summing over  $R$  simulated  $P(\beta_i, x_i)$  with  $\beta_i$  drawn from  $F(\beta | \mu, \Omega)$ . These draws can be obtained randomly using a pseudo-random generator but more recently, systematic methods, such as Halton draws, have proved to be more efficient (see Train (2003) for further details). The simulated probability is:

$$SP_i = \frac{1}{R} \sum_{r=1}^R P(\beta_i^r, x_i), \quad (3)$$

where  $\beta_i^r$  is the  $\beta_i$  from the  $r$ th draw from  $F(\beta | \mu, \Omega)$ , for event  $i$  and  $R$  is the number of draws. Thus the simulated log-likelihood function for the RPL is:

$$SL = \sum_{i=1}^N \log \left[ SP_i^{y_i} (1 - SP_i)^{1-y_i} \right], \quad (4)$$

which depends on  $\mu$  and  $\Omega$ . The maximum-likelihood estimates of those parameters (given their chosen initial values) are obtained with iterative numerical optimization procedures (see Train (2003) and Hensher and Greene (2003) for further explanations). Additionally, we remark that the mixed logit allows for heteroskedasticity in the error term, depending on the explanatory variables. Therefore we conclude that the mixed logit is more flexible than

standard logit, and tests can be applied to determine whether the extra flexibility is needed for fitting the data.

## 5. EMPIRICAL FRAMEWORK

In this paper, we estimate a mixed logit model to analyze the determinants of radical Islamic terrorism in Europe, the USA and Canada for October 1979 to December 2002. The choice of countries is based on the observed emigration from Islamic countries to the industrialized western nations (Clutterbuck 1975). We estimate the probability of a terrorist attack with certain characteristics, which define the type of attack, being perpetrated by an Islamic group, that is,  $\text{Prob}(\text{Islamic}|\text{type})$ . As mentioned earlier, this is a statistical, rather than a behavioral model. Behavioral models are not adequate in the present framework and are beyond the scope of this paper. We therefore use no motivational variables, rather relying on a statistical model that fits the probability of Islamic terrorist actions, given their particular attributes.

We adopt the definition of Enders and Sandler (2004): "terrorism is the premeditated use or threat of use of violence by individuals or sub-national groups to obtain a political or social objective through intimidation of a large audience beyond that of the immediate victims". On the basis of this definition, we estimate the above-mentioned probability for event  $i$  as,

$$\Pr(\text{Islamic}_i | v_i) = \int_{-\infty}^{+\infty} P(\beta, v_i) N(\beta_5 | \mu_5, \sigma_5) d\beta_5 \quad (5)$$

with  $N(\bullet)$  the normal distribution, and

$$v_i = \beta_0 + \beta_1 \text{assass}_i + \beta_2 \text{armed}_i + \beta_3 \text{arson}_i + \beta_4 \text{bomb}_i + \beta_5 \text{cas}_i + \beta_6 \text{USvicsout}_i + \beta_7 \text{Fran}_i + \beta_8 \text{Ger}_i + \beta_9 \text{Ital}_i + \beta_{10} \text{Switz}_{it} + \beta_{11} \text{UK}_{it} + \beta_{12} \text{US}_{it} \quad (6)$$

We chose the variables from the ITERATE data set, on the basis of their availability. Here *Islamic* is a dummy variable, equal to one whenever the attack was performed by radical Islamic terrorists. ITERATE does not specify radical Islamic attacks, but identifies the first group initiating the action. From the list, we have chosen the Islamic groups. Some of this plethora of Islamic groups may not be radical in their nature, but since we are considering terrorism in Europe, the USA and Canada, we assume that almost all Islamic groups perpetrating terrorist attacks in the western countries are radical. We have excluded, for instance, the PKK (Kurdish People's Liberation Front), in view of its well-known secular nature. In the Appendix to this paper, we include the list of the groups appearing in our data

that we consider to be radical Islamic. There are some terrorist events in the ITERATE data set committed by unknown groups (24%). In such cases, we have considered these terrorist events to be non-Islamic, since they are more probable than the Islamic. However, this procedure may introduce some contamination into the model.

*Armed*, *Arson*, *Assass*, and *Bomb* are dummy variables based on ITERATE's identification of types of incident, which accounts for 25 types of terrorist actions, from which we selected the most common. We considered armed attacks (*Armed*), including armed attack employing missiles, armed attacks--other, including mortars, bazookas, and shoot-outs with the police; incendiary bombing, arson and Molotov cocktails (*Arson*); assassination (*Assass*); bombing (*bomb*) which includes explosive bombing and car bombing; kidnapping; letter- or parcel-bombing; and aerial hijacking. Suicide attacks have not been considered because there were only 4 in the sample, i.e. those accounting for the September 11 attacks. Some types have been dropped from the model, due to their statistical insignificance in a previous analysis.

*Casualties* is a continuous variable which results from adding together *wounded* and *killed*, identified by ITERATE respectively as the number of individuals wounded and the number of individuals killed. These two variables are highly correlated (with correlation coefficient equal to 0.97), so that when we introduced both into the model, only *wounded* is statistically significant. Therefore, we decided to combine the information of both variables by considering the number of casualties instead. We have also considered the number of US citizen victims outside the USA (*US vics out US*), in order to take into account the targeting of the USA claimed by radical Islamic terrorist groups.

*Fran*, *Ital*, *Ger*, *Switz*, *UK* and *US* are dummy variables representing the country where the event took place, based on ITERATE's identification of the end location of the terrorist event. ITERATE identifies the starting and ending locations. For roughly 98% of the events, the starting and ending location of a particular event are identical. Differences in starting and ending locations result from hijacking, which was not statistically significant in the previous analysis and therefore, is not an explanatory variable in our model. In a previous analysis, we also considered *Spain*, but in all of the models that we applied, this was not a statistically significant variable. The chosen countries are based on their being considered as representative of western society in terms of dimension and political involvement in international affairs. Furthermore, these are the western countries, except for Greece, with a higher annual average incidence of terrorism events in the period (Blomberg et. al., 2002). Switzerland was included due to its high rate of Islamic terrorist attacks.

Intervention variables were not taken into account, because it is not clear what these are for this type of event. The relative level of terrorist activities depends on three factors: The relative costs between legal and illegal activities, the relative gains between the two types of activities, and the total resources available. Efforts to curb the funding of radical Islamic terrorist groups are not documented, thus preventing the definition of this variable. Other traditional intervention variables, such as the introduction of metal detectors in airports, are not specific to this type of terrorism and merely cause substitution among various modes of operation (Enders and Sandler, 1993). The main modes of intervention deployed against radical Islamic groups are preemption and deterrence, applied through the intelligence and security agencies, together with the usual procedures applied to counter organized crime. A further reason for not considering additional variables is because the ITERATE data set is established on a daily basis and consequently, will display very small variations within this type of sample. The above-mentioned potentially exogenous variables are not available on this basis. If we aggregated the data set to introduce additional variables, we would then have count data of radical Islamic events, which would preclude the use of the mixed logit model. The non-consideration of preemption and deterrence variables may induce the omitted variable bias in our model, if these politics have determinant different consequences on Islamic terrorists opposed to non-Islamic. On the other hand, preemption and deterrence may influence mainly the type of attack, and therefore, indirectly, they are considered in the model.

## 6. EMPIRICAL RESULTS

Time series data on terrorist incidents is found in the ITERATE data base from 1968 to 2002, available from Mickolus (edwardmickolus@hotmail.com). We restricted the data span to the period October 1979 to December 2002. The initial data frame is based on Enders and Sandler (2000), who established that the rise of fundamentalist terrorism started in the fourth quarter of 1979. The final period is defined by the availability of the data. We gathered a total of 2,799 observations.

Table 3 presents the descriptive statistics of the data.

We verify that most of the data set comprises dummy variables, with two continuous variables: *casualties* and *US victims out of US*.

Table 3: Descriptive Statistics of the Data

Variable	Description	Minim.	Maxim.	Mean	Standard Deviat.
Rad. Islamic (Dependent)	Equal to one when the event is radical Islamic and zero otherwise	0	1	0.1379	0.3449
Armed Attack	Equal to one when the event is an armed attack and zero otherwise	0	1	0.0582	0.2342
Arson	Equal to one when the event is incendiary bombing, arson or Molotov cocktail and zero otherwise	0	1	0.1390	0.3460
Assassination	Equal to one when the event is an assassination and zero otherwise	0	1	0.0890	0.2847
Bomb	Equal to one when the type of the event is bombing and zero otherwise	0	1	0.3816	0.4859
Casualties	Total number of individuals wounded plus individuals killed	0	5053	4.0189	96.5040
US victims Out of US	Number of US victims in countries other than USA	0	200	0.3844	5.6459
France	Equal to one when the event occurs in France and zero otherwise	0	1	0.1529	0.3600
Germany	Equal to one when the event occurs in Germany and zero otherwise	0	1	0.1936	0.3952
Italy	Equal to one when the event occurs in Italy and zero otherwise	0	1	0.0707	0.2564
Spain	Equal to one when the event occurs in Spain and zero otherwise	0	1	0.0772	0.2669
Switzerland	Equal to one when the event occurs in Switzerland and zero otherwise	0	1	0.0207	0.1425
UK	Equal to one when the event occurs in the UK and zero otherwise	0	1	0.1411	0.3482
USA	Equal to one when the event occurs in the USA and zero otherwise	0	1	0.1115	0.3148

To estimate the mixed logit model, we used a simulator for RPL on the Gauss programming language, available in Kenneth Train's home page<sup>2</sup>. Other results were obtained with TSP.

We present a standard logit model and the mixed model for comparative purposes.

As we have previously mentioned, *Spain* was not statistically significant in any of the models used, thus it was eliminated from our analysis. Focusing on the adequacy of the standard logit model, we implemented the RESET test. The result gives evidence of misspecification of the logit model. This may be due to the presence of unobserved heterogeneity, depending on the aforementioned explanatory variables. We applied the HAL test of Chesher and Santos-Silva (2002), using likelihood ratio procedures to test against this type of heterogeneity. First, we considered that it was dependent on all the explanatory

<sup>2</sup> <http://elsa.berkeley.edu/~train/Ps.html>.

variables. Next, we applied a classic selection procedure. The results display evidence of unobserved heterogeneity depending on *Bomb*, *Casualties*, and *Switzerland*, inducing the estimation of a mixed logit with random coefficients for these variables. However, the hypothesis that *Bomb* and *Switzerland* have a random coefficient was rejected and consequently, we considered *Casualties* to be the only source of random effects. The final results can be seen in Table 4.

Table 4: Parameter estimates and t-statistics

Variables	Standard Logit		Mixed Logit	
	Coefficients	t-stat	Coefficients	t-stat
Intercept	-1.3417	-11.09	-1.3386	-10.07
Armed Attack	-0.5789	-2.28	-0.8425	-2.63
Arson	-2.3295	-6.31	-2.4151	-6.03
Assassination	0.4533	2.74	0.6371	2.68
Bomb	-1.0542	-7.45	-1.3832	-8.04
Casualties	0.0157	3.92	-0.4471	-1.58
US vics out US	0.0299	1.75	0.0307	1.14
France	0.3749	2.32	0.3574	1.86
Germany	-0.6297	-3.31	-0.7436	-3.51
Italy	0.5943	2.96	0.7303	3.17
Switzerland	0.7496	2.32	0.9308	2.67
UK	-0.4389	-2.03	-0.5242	-2.01
USA	-0.4673	-2.19	-0.5749	-2.40
<i>Random Effects</i>				
Casualties			1.2065	2.65
Observations	2799		2799	
LogLikelihood	-1002.02		-982.41	
<i>Specification tests:</i>	Statistic	p-val.		
RESET on stand. Logit	-2.579	0.01		
HAL on standard Logit	20.379	0.000		
LR: standard vs Mixed	39.22	0.000		

RESET: Detects misspecification in the logit model and was performed with  $\hat{\beta}'x_i^2$ ;

HAL: Detects evidence of heterogeneity in the logit model depending on *Bombing*, *casualties* and *Switzerland*.

LR: Likelihood ratio test

Taking into account the mixed logit, the probability of an attack being Islamic increases if the attack results in assassination. Furthermore, terrorist attacks taking place in France, Italy and Switzerland have a higher probability of being Islamic, whereas for those in the UK and the USA, this does not appear to be the case. On the other hand, attacks that are armed, or involve bombs or arson have a lower probability of being Islamic. While the number of US victims and the number of resulting casualties were statistically significant for the standard logit, for the mixed model they were not. Nevertheless, we can not reject the possibility that *casualties* has a random coefficient (with estimated standard deviation equal

to 1.21), neither can we reject the possibility that the average of the coefficients in the population is zero. This signifies that for half of the events, the coefficient is positive and for the other half, it is negative.

Comparing the standard logit with the respective mixed logit by means of an LR test, we obtain a test statistic with p-values equal to 0.00, denoting that the mixed logit is the more appropriate specification.

The fact that a parameter is random, opposed to non-random means that the effect of this variable has a widespread variance, signifying that it varies greatly along the sample. Therefore, there are terrorist events with few casualties that have a high probability of being Islamic and an equally high probability of this origin for others with many casualties. Confronted with this result, the non-random results are more predictable, and when it is said that the UK has a negative probability of experiencing a radical Islamic attack, this signifies that Islamic terrorist acts are less likely to happen in the UK, due to deterrence enforcement, or because Islamic terrorists do not target this country systematically.

The general picture is in accordance with the perception obtained from the media. The UK and the USA are not preferred targets of radical Islamic terrorism.

## **7. CONCLUSION**

In this paper, we have estimated the probability of terrorist attacks being of a radical Islamic origin, given the attributes of the attack, for countries in Europe, the USA and Canada, using a mixed logit model and data referring to terrorist events for the period October 1979 to December 2002, obtained from the ITERATE data set. Taking into account the mixed logit, we conclude, first, that spatial heterogeneity related to Islamic terrorist attacks exists among countries analyzed, with such attacks being more prevalent in Switzerland, France and Italy and less prevalent in Germany, the UK and the USA. Second, attacks that result in assassination have a higher probability of being Islamic, while those resorting to bombs, arson, or armed attacks reduce this probability. Finally, we conclude that heterogeneity exists in the variable the number of casualties.

These results characterize the probability of terrorist attacks being Islamic as a function of the target country and the type of attack: What is the appropriate policy in this context? First, Switzerland, France and Italy should allocate more funds to counteract this type of terrorism. Second, the prevention and deterrence policies should take into account the evidence that, contrary to the Al Qaeda attacks, conventional Islamic attacks in Europe and

North America rely more on assassination and less on bombs, arson or armed attacks. Policy-makers and enforcers should also be aware that Islamic terrorists may cause more US victims outside the USA, though the statistical insignificance of the parameter of this variable when heterogeneity is taken into account (possibly due to a lack of precision) induces some caution on this conclusion. Third, the heterogeneity in casualties may mean that Islamic terrorist attacks can have very different results, ranging from high to low levels of this effect. This is the main result of the paper, and the policy implication is that adequate prevention and deterrence measures should always be in place, since the consequences in terms of casualties threatens to reach staggering proportions. Finally, the asymmetric targeting of the Islamic attacks of the different European countries means that a common European policy towards this threat will be difficult to achieve.

The September 11, 2001 and March 11, 2004 attacks reinforced the perception that radical Islamic terrorist events have changed in terms of scale, type of attacks and countries targeted. Such extraordinary acts of terrorism call for extraordinary policy responses, including undertaking stringent preventive action, such as the laws currently enforced. Nevertheless, in the long run, according to the data set, it seems that we may expect the low frequency of terrorist activity in Western Europe and North America to be maintained, similar to that observed throughout most of the period studied. This possibility, very clearly, cannot allow the authorities and citizens to indulge in any degree of complacency or to relax their vigilance. Policies and strategies to counteract the phenomenon need to be permanently in place.



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## **ANNEX: *ITERATE* ISLAMIC GROUPS INCLUDED IN THE DATA**

0044 Islamic Guerrillas in America  
0047 Imperial Iranian Patriotic Organization  
2103 People's League of Free Palestine  
2224 Palestine Resistance  
2232 Committee for the Safeguard of the Islamic Revolution  
2243 Committee of Solidarity with Arab and Middle Eastern Political Prisoners  
3525 Palestinian Revenge Organization  
3803 Malmo Muslims Jihad  
6149 Salafist Group for Preaching and Combat (Algeria)  
6154 Algerian Secret Service  
6156 Algerian Fundamentalists  
6157 Islamic Armed Group (Algeria) (GIA)  
6158 Algerian Islamic Salvation Army (AIS)  
6159 GIA - General Command (Algeria)  
6200 indeterminate Libyans  
6202 People of Omar  
6204 Libyan Agents  
6205 Green Brigades  
6206 National Front for the Salvation of Libya  
6207 Al Borkan Volcano Libyan Organization  
6209 Libyan Organization of 7 April  
6210 Libyan Revolutionary Committee  
6298 Iranian Exiles  
6301 indeterminate Iranian guerrillas  
6302 Iranian students  
6303 IPS Peoples Strugglers Mujahiddin e Kha  
6306 Islamic Jihad Organization  
6309 Political Organization of the Arab People  
6316 Iranian National Liberation Movement-Red  
6317 Revolutionary Islamic Organization  
6318 Guards of Islam Guard Corps of Islam Group  
6320 Azadegan Freedom Seekers Iranian monarchicals  
6321 Peykar Muslim Protest  
6322 Feda iye Khalq Mujaheddin e Khalq  
6324 Fedayen-e-Islam led by Ayatollah Sadegh  
6327 Martyrs of the Islamic Revolution  
6328 Iranian intelligence agents  
6329 Islamic Revolutionary Movement  
6331 Hezbollah  
6332 indeterminate Shi'ite moslems  
6334 Fedayeen of the imperial Iranian monarchy  
6335 Martyrs of the Iranian Revolution  
6336 Sons of Imam al-Hoseyn ibn Ali  
6337 Iranian Revolutionary Guard

6338 Iranian People's Fedayin Guerrillas  
6339 Guardians of the Islamic Revolution  
6341 Islamic Revolution Organization  
6397 The Western Thrace Islamists (Islamistas Dhitikis Thrakis) (Turkey)  
6446 Hawari Group (Pro Iraqi) (Iraq)  
6448 indeterminate Iraqi guerrillas  
6449 Iraqi Agents  
6455 Iraqi Mujahidin Islam  
6463 Iraqi Islamic Amal Organization  
6467 Organization of Iraqi Islamic Action  
6506 Vanguard of the Conquest (Egypt) (Talai al Fath)  
6509 The Muslim Group (al-Jama'a al klamiyah) (Islamic League of Those Applying the Book and the Sunnah) (Egypt)  
6521 Muslim Brotherhood  
6530 Syrian agents  
6533 Syrian Mujaheddin  
6624 Imam Musa as-Sadr Brigades Imam as-Sadr  
6625 Movement of Arab Revolutionary Brigades  
6627 LARF Lebanese Armed Revolutionary Faction  
6630 indeterminate Jordanian  
6640 Islamic Liberation Front  
6658 Hamas (Islamic Resistance Movement) (Palestinian)  
6659 Al Tawhid (Palestinian)  
6670 indeterminate Arab/Palestinian guerrillas  
6671 PFLP Popular Front for the Liberation of Palestine  
6672 AOLP Action Organization for the Liberation of Palestine  
6673 Al Fatah  
6674 BSO Black September  
6679 PFLP-GC PFLP-General Command  
6686 PLO Palestine Liberation Organization  
6695 Arab Liberation Front  
6700 Fatah Force 17  
6702 Palestinian Resistance Jaffa Squad (Palestine)

6706 Usama Bin Laden (Al-Qaeda) (The World Islamic Front for Jihad Against Jews and Crusaders) (Islamic Army for the Liberation of the Holy Sites)  
6711 15 May Arab Organization  
6712 Fatah-Revolutionary Council Abu Nidal Gr  
6713 Al Asifah headed by Abu Nidal  
6714 Black June headed by Abu Nidal  
6725 Group for Martyred Islam as-Sartawi  
6726 Movement for Rebuilding Fatah  
6727 Islamic Revolutionary Guard  
6728 Revolutionary Organization of Socialist  
6729 Martyrs of Tal Zatar Organization  
6730 indeterminate Abu Nidal guerrillas  
6731 Liberation of Palestine  
6732 Secret Army for the Liberation of Palestine  
6733 Arab Revolutionary Cells  
6734 Arab Revolutionary Front  
6735 PLF Palestine Liberation Front  
6739 Islamic Resistance Front  
6740 Martyrs of Palestine Abu Nidal group  
6743 Abu Musa Organization  
6744 Arab Combatants  
6745 Organization of Islamic Justice  
6750 Union of Imams (Jordan - al Qaeda)  
6991 al Jame'ah of International Justice  
6995 The Basics of the Islam (Palestinian)  
6997 Ansar'e Hizballah (Iran led by Hossein Allah Karam)  
7001 People's Mojahedin of Afghanistan  
7505 Kashmir Liberation Army  
7513 Jammu and Kashmir Liberation Front